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The role of traditional knowledge in climate change adaptation among the Nicobarese of Central Nicobar Islands, India

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A qualitative study guided by phenomenological approach was conducted during 2016-2018 to understand the experience of living amid climate change among the Nicobari tribes living in Central Nicobar Islands and their management practices evolved for adaptation over the years. The study showed that the economic prosperity and sustainability of *Nicobarese* basically depended on their traditional wisdom to mange land resources under their possession and farming practices as indicated by the strength (>6.0) of anecdotal network analysis which are evolved over the years, are found to be climate resilient. They have wealth of knowledge on island biodiversity particularly on pandanus, banana, tubers, roots and leafy vegetables besides coconut. Nicobarese also learnt the process and storage of surplus farm produce for longer duration under the existing climatic conditions. The anecdotal network analysis of nine climate change adaptation measures and eight climate change events showed that seasonal calendar and organic waste management were the best climate adaptation strategy known to tribes followed by community land use / holding.

Keywords: Biodiversity, Climate change, Indigenous Knowledge, Network analysis, Land management

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In recent times global climate change and food insecurity have emerged as the major challenges for humanity[1]. Climate change and variability affect the agricultural sustainability whereas anthropogenic activities accelerated the process of natural resources degradation with the consequent impact on food production. Changing rainfall pattern (-6.9 to+12.4%) with increasing extreme events (rainfall intensity and cyclonic storm), increase in average air temperature (0.84 to 2.10°C), and sea level rise (2 to 3.5 mm y^{-1}) are already affecting global food production systems and projected to become intensive in the future (2040-2069 period) without mitigation measures[2]. Averting this challenge requires that farmers adapt by making changes in farming and land management decisions[3]. When farmers amend their practices suffering from weather changes, local knowledge gained over generations could be more useful in sustaining their livelihood. This is more pertinent to Nicobar Islands, India which is already experiencing climatic variations and projected to be affected by climate change events[4]. At the same time, past experiences revealed that the native tribal community has evolved traditional wisdom to manage their limited resources and adapt to natural challenges. In other words, the role of indigenous knowledge is well recognized on resource management, traditional medicine, biodiversity management and disaster risk reduction[5]. For this reason 'traditional knowledge' has gained importance in recent past for optimum utilization and management of dwindling natural resources.

The distinct knowledge of a community which encompasses the cultural traditions, values, beliefs, and understanding of local people is referred as traditional knowledge[6]. Indigenous communities have traditional knowledge in predicting weather and climate, to plan their activities and also to respond to climate risk factors[7]. Alternatively, the global or regional level climate change studies fails to predict the site specific climate data and scenarios where only generalized predictions were given for a larger area. Thus understanding the basis of local knowledge is critical for developing adaptation strategies and long-term community resilience[8]. In recent times, the traditional knowledge in climate change adaptation is documented in many parts of the world[9-11] and in mainland India[12].

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As climate change increasingly impacts indigenous landscapes, communities are responding and adapting in unique ways. The *Nicobari* tribe is one of the major indigenous communities inhabiting in Nicobar group of islands and several scientific studies have documented their traditional knowledge[13,14]. Yet specific focus on understanding traditional knowledge through tangible heritage of these communities that are linked with the surroundings and climatic factors is lacking. At the same time, study of traditional knowledge has gained significance since the December 2004 Indian Ocean tsunami, towards conservation and providing livelihoods with inter disciplinary perspective. The Nicobari tribe has fair knowledge about the nature of resources under their possession and the ways to utilize them judiciously for their well being in harmony with the natural factors in the fragile island ecosystem. Thus, the present study was undertaken with the objectives of (i) documenting the traditional knowledge of Nicobari tribes in resource management for farming (ii) to assess the extent of utilization of this knowledge in sustaining the farming activities in relation to recent climate change events in the tribal areas.

Methodology

Study area

The Nicobar Islands, India is a chain of twenty two Islands stretching from 9° 17′ 48″ North latitude and 92° 42′ 15″ East longitude surrounded by Bay of Bengal in the west, Indian ocean in the south and Andaman Sea in the east. The Nicobar group of islands is divided into northern, central and southern group of islands in which the *Nicobarese* inhabit the central group of islands consisting of Chowra, Teressa, Bompuka, Katchal, Kamorta, Nancowry and Trinket Islands. Each island has its own identity in terms of original folktales, material traits, and island specific rituals[15].

These islands experience hot and humid climate with annual average rainfall of 2800 mm. However maximum rainfall is received from June to November and evapotranspiration exceeds precipitation during the remaining months making it water deficit[4]. These islands suffered the maximum damage during the December 2004 Indian Ocean tsunami. Their coconut and areca nut plantations were worst affected and the coastal infrastructures were badly destroyed. In the subsequent year these islands experienced drought like situation during summer months with decreasing number of rainy days and increased tropical deep depressions (0.5%) during monsoon period. The decadal climatic data (2010-19) showed that beginning of the rainy season has become unpredictable followed by an unexpected long break in monsoon rainfall. In spite of this, *Nicobarese* recovered swiftly from the trauma of the disaster with their traditional knowledge in resource utilization and adaptation.

Data collection and sampling procedure

The present study aimed at understanding the traditional knowledge on management of agriculture for climate change adaptation by the *Nicobarese* of the study area. A qualitative study guided by phenomenological approach was conducted during 2016-2018 to understand the experience of living amid recent climate change among the tribes and their management practices evolved for adaptation over the years. The phenomenological methodologies account for peoples understanding of their lived experiences of a phenomenon and also articulate the meanings associated with those experiences.

In this study, purposive sampling was adopted due to the specialized nature of study involving indigenous knowledge, climate change and agricultural management. A total of 50 respondents comprising of village captains, *tuhet* heads, tribal elders and farmers group besides agricultural department officials were selected (Supplementary Table S1). Basic resource use information, cultivation practices and climate change perception were collected from the tribal leaders and elders from each *tuhet* including both men and women. Conversations were structured around the questions shown in Table 1 and took place mostly in the tribal language and Hindi. Facilitators encouraged participants to expand on the questions and allowed additional discussion. In addition, data from secondary sources, field survey and remote sensing based information were collected and used. Information on climate data was collected from ICAR- CIARI, Port Blair, India Meteorological Department and downscaling of global level data sets for understanding climate change over Nicobar Islands.

Data analysis

The principal theme areas emerging out of the information collected from interviews, discussions and secondary sources were identified and were used for generating findings to give meaning to the study based on its objectives. In documentation, manual method is used without any statistical software analysis. The data validation was done by comparing

Table 1 — Questions asked in structured discussions with respondents

Sl. No.	Questions	Purpose	Validation
1	How much cropped area or coconut trees do you own?	Evidence gathering	Within group consensus / Primary data
2	Where do you get your planting materials / seeds?	Evidence gathering	Validated with farmers from other groups
3	Do your tuhet own tuhet garden? How much area?	Verification	Validated with farmers from other groups
4	Does your village own common property land with coconut?	Verification	Within group consensus
5	How do you benefit from mixed jungle located in the centre of your island?	Evidence gathering	Within group consensus / Secondary data
6	Which crops do you grow in your garden?	Evidence gathering	Within group consensus / field survey
7	Is there any change in the yield in the crops you grow?	Evidence gathering	Within group consensus / secondary data
8	How do you know crop yields are changing?	Verification	Validated with farmers from other groups
9	In your opinion, what the reason for decreasing crop yield?	Opinion scoping	Primary and secondary data
10	Other than crop yield what are all the changes do you observe in your garden?	Verification	Validated with farmers from other groups / lab analysis
11	What is your main diet? What do you prefer during special occasions?	Evidence gathering	N/A
12	During drought / dry season what is your main diet? Where do you get them?	Evidence gathering	Within group consensus /field survey
13	From your long observation of nature, do you feel that climate is changing?	Opinion scoping	Validated with farmers from other groups / primary data
14	What are its indications? Any ill effects on farming	Inference	Validated with farmers from other groups
15	Are these changes already known to you? How?	Inference	N/A
16	What measures do you and your *tuhet* follow to avert the ell effects?	Inference	Within group consensus / field survey
17	What are all the land management measures you follow in every year?	Evidence gathering	Validated with farmers from other groups
18	Is it enough to cope with the changing climate? If not, what more is required?	Inference	Validated with farmers from other groups / field survey
19	How do you process and store coconut and other farm produces?	Verification	Within group consensus
20	Please rank different adaptation methods based on its usefulness	Verification	Validated with farmers from other groups

and integrating the data collected from various methods and or sources to confirm the validity and trustworthiness of the results. Besides, anecdotal network analysis (ANA) was done to find out the uniformity or homogeneity of the information provided by the respondents and understand the link between traditional knowledge *vis-à-vis* climate change adaptation, respectively.

Anecdotal network analysis (ANA)

In order to understand the link between traditional farming knowledge *vis-à-vis* climate change adaptation 'anecdotal network' was constructed based on the information provided by farmers group. In our network the interaction strength (shown graphically by the width of the connecting lines) indicates the number of farmer groups that cited an interaction. We assumed that the more farmers that cited an interaction, the more confidence we could have that this interaction exists, therefore the line width can be seen to represent a proxy for confidence in the information. The network analysis was performed by using "R" statistical software version 3.0.1 (R_Core_Team, 2013).

Results

The study revealed a wide range of traditional knowledge on their major agricultural activities such as distinct land holding and use pattern, existence of multistory & multipurpose gardens, seasonal farm activities, processing and storage and exploitation of plant resources for family health and nutrition. This traditional agricultural practices have evolved around adaptation to the changing climatic parameters on which some of the tribal elders have fair knowledge[4].

Adaptation strategies

Land holding and land use pattern

In general, the tribal society owns the entire land under cultivation and no individual ownership of land rights are allowed even today. Only *usufructury* rights are given to the individual family in a *tuhet* by its *ma-tuhet* (lineage head) for cultivation. Even the homestead and plantation area is identified with their lineage and clan names only. With increase in population and formation of new *tuhet,* virgin areas inside the forest are cleared by all the *tuhet* members / villagers on mutual cooperation. During April-May, they clear the new areas owned by tuhet / village and

burn the dried twigs and residues. Initially tubers and banana will be planted as intercrop between the *tavok* (coconut saplings) in the cleared plot till the coconut is established into a dense plantation.

Analysis of crop distribution revealed that there are three different segments by which the coconut (sometimes coconut + tuber + traditional vegetables) plantations are maintained in every island. In the central highland or elevated portion of the Island the giant coconut trees are mixed with dense forest and left undisturbed where natural crossing and selection is probably continuing. The second segment of the land use is large and mostly used for copra production which is allocated among the tribal members through the *tuhet* system. The third segment comprises of coconut grown in and around their settlements which are normally selected and planted by them for domestic purposes. The first and second segment is totally rainfed and the third segment around the tribal household benefits from domestic waste water.

Multipurpose home gardens

Multipurpose home gardens are the common feature in any tribal area, which is the horticultural plantation area commonly known as *pano-o* in Nicobari parlance. In addition to shifting cultivation based establishment of coconut garden, *Nicobarese* maintain *tuhet* garden (common to a *tuhet*) and home garden (belongs to individual family) to meet their household needs (Supplementary Fig. S1). Major varieties of tubers like *kupeng* or *takinhi*, *kunya*, *kani* or *nya*, *it-seaichtahangen*, and *malayali alu* are planted in June. Locally adapted varieties of *kanoh* (coconut), *laeom* (pandanus), *ictusa* (indigenous cotton), *chamam* (wild arecanut), *pubai* or *sampet* (papitha), banana (*tayuknog* or *hipu*), *kinreai* (Jackfruit), *manga* (Mango), *sealakaroch* (wild orange), *payuoh* (wild fruits), *kumiyanta* or *hiluli* (small size green chilli), *siea-tahlava* (elongated banana), *kööfee* (wild clustered apple), *limong* (wild variety of lemon), *thak / chaf* (*katta* or wild tamarind) were commonly found in the garden. Sometimes segmentation of plants into a separate unit is practiced in the garden based on the topography and runoff water. Water requiring crops are normally planted in the lower portion of the garden. In addition, the vegetables like *alithong* (brinjal), *panchalu* (bitter guard), *makka* or *miloh* (maize), ridge guard, okra, beans, bottle guard, drum stick, *kumda*, *kundru*, lemon, and banana (*tayuknog* or *hipu*) are cultivated in home gardens. The farm produce is mostly used by the individual household and the surplus is shared with other *tuhet* members. This biodiversity garden[16] (Fig. 1) act as a buffer against variation, change and catastrophe[17].

Multistory cropping

Due to the limited land availability for cultivation in these islands local people have evolved a system of multistory cropping by integrating naturally growing understory plants, creepers, climbers and trees with long poles. In one of the cases beetle leaves, leafy vegetables and coconut / arecanut trees are found growing around their settlements or in home gardens. Two varieties of betal leaves (*Piper betle L.*) are recognized by the people based on the size and texture of the leaves (Table 2). *Roilong* and *Roi Haei* are the two varieties recognized by them which are used for chewing along with arecanut and lime for improving digestion, curing stomach ache in children and also used as bio pesticides.

Nicobarese can recognize wide variety of consumable wild leaves grown on the banks of streams, estuaries, and their backyard that are consumed after processing (Fig. 1 a-c). The fresh coconut milk is used as additive in preparation of vegetable leaves. *Roi-takappu* is a kind of wild vegetable leaf found on a vine plant and found profusely in the forest even under shaded conditions. The leaves are plucked and consumed after thorough roasting on frying pan. It is used as vegetable mixed with fish and coconut milk. Other wild leaves consumed by the *Nicobarese* are mainly *tilfung*,

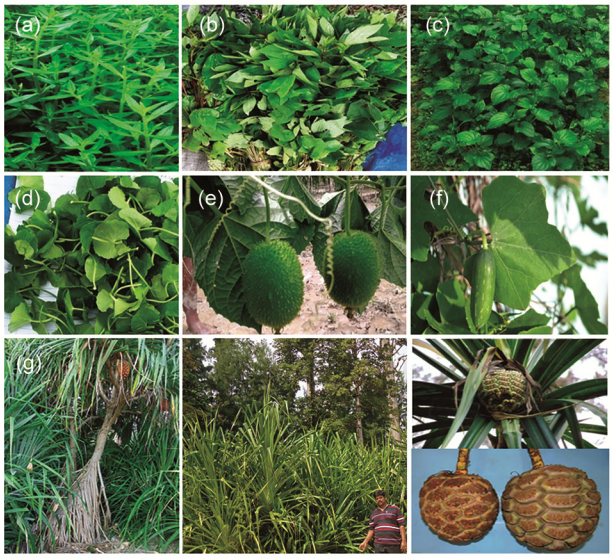

Fig. 1 — Diversity of crops used by Nicobarese adapted to climatic variations (a, b & c are leafy plants; d, e & f are vines; g is bush)

Table 2 — Characteristics of identified local types of betel leaves and leafy vegetables

Name & Diversity index	Varieties / local types	Description and purpose	Climate adaptation
Betal Leaves (Pan) *Piper betle* L. (0.54)	*Roilong* (Big Size thick *Pan* Leaf):	It is used for chewing along with areca nut and lime	Grows in all places and improves the digestibility of non-vegetarian diet during rainy season
	Roi Haei (Small Size soft *Pan* Leaf)	It is also used for chewing purpose	
Leafy vegetables (0.8)	*Roi-takappu*	Used as leafy vegetable	Grow even under shaded condition and serves as a trap crop in the garden.
	Vurong (Hibiscus cannabinus)	Used as leafy vegetable, rich in iron	
	M*eetabaaji* (*Linkong)*	Used as leafy vegetable	
	Roi-kumda	Provide fruits and vines as vegetable	

vurong (*kattabaaji* or leaves of H*ibiscus cannabinus*) *roiturilö*, *roikucho-ön*, *roinya-ön*, *sajnabaaji*, *roitukapo*, *roi-kumda*, *linkong* (*meetabaaji*), *roilimpop, roiparethi, kuvat, roi likol* etc. These leaves are rich in iron, phosphorus, and micronutrients and generally used as food supplements.

Traditional fruits (*KulÖl TanyukngÖ*)

Unlike cultivation of plants in multipurpose garden, pandanus (*laeom*) and banana (*hipu*) are found widely distributed with great diversity (0.81 to 0.92) throughout the island and form the most important component of Nicobari diet (Supplementary Table S2). The locals recognize different types of pandanus based on palatability, size, shape and location. This can be verified from many scientific studies indicating the presence of different pandanus species (*Pandanus dubius* var. andamanensium, *P. furcatus, P. lerum* var. lerum, *P. odorifer* and *P. tectorius*) and genus *Freycinetia insignis* (climbing screw pine) throughout the Islands[18]. Among them *P. lerum* var. *lerum* is the most important species known as Nicobar bread fruit, having great potential considering its food, nutritive, medicinal and household uses (Fig. 1 g). In sea front wild type pandanus are promoted along with other littoral species that act as bioshield against sea erosion, waves, sea surges etc.

Similar to pandanus, wide range of banana are abundantly found around their houses, plantation, multipurpose garden and in forest. As such Nicobarese identify different varieties based on its taste, size and quality (Fig. 2). They belong to *Musa paradisiaca*, *M. balbisiana* v. *balbisiana, M. balbisiana v. andamanica, M. indandamanensis* and *M. acuminatoa*[19,20]. Nicobarese prefer banana in their diet in the form of vegetable as well as ripen fruit. In promotional system, healthy suckers from other tribal villages were collected or selected from multipurpose gardens to establish new banana plantations and allow

Fig. 2 — Diversity of locally adapted banana found in Nicobar Islands

2 to 3 ratoon from each plant that help them to manage certain pest and diseases. Most of the plants growing in the forest are seeded type which probably favour new gene combinations that may provide climate change adaptation with desirable characters. During summer months they cover the soil with long leaves collected from the forest.

Seasonal calendar (*Hinruolo-kahe*)

The agricultural practices carried out in different gardens and in coconut plantation is regulated by seasons, for which *Nicobarese* developed their traditional calendar based on different seasons by which they undertake cultivation and other economic activities (Fig. 3). According to the tribal elders, the seasons are broadly divided into *sikehagö* (summer season) *sung* or *yuuch* (rainy season). Onset of southwesterly winds from sea indicates the arrival of rainy season while the change of wind direction marks the withdrawal of rains and onset of dry

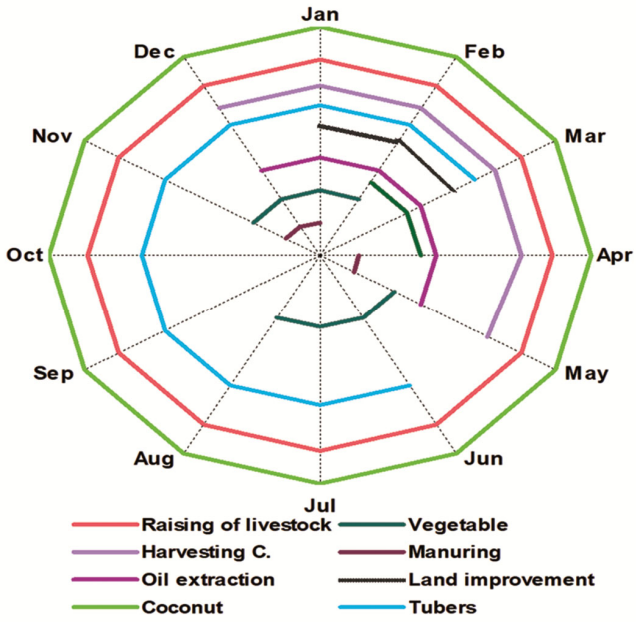

Fig. 3 — *Hinruolo-kahe* (Seasonal Calendar) of the *Nicobarese*

months. Accordingly, after Christmas and New Year celebrations, bush cleaning and firing in January (Ranch) is carried out followed by *Hachuhha-un* (fencing) in March and *Hakon panô-o* (Dibbling seeds/ plants) in April is carried out. *Vito-an panò* (late gardening works) is carried out from May to June. From *Ranch* or *Sung* onwards *Nicobarese* harvest *kinreai* (jackfruit), mango, jamun etc., from their garden as well as from the forest. Its seeds (*kulal)* are preserved for consumption in rainy season or sowing at pre-monsoon season. It is their custom that avoids harvesting of tubers during peak monsoon season. Further, the seasonal calendar indicates limited socio-economic activities are limited during dry period. They do restrict fishing activity during March–April to avoid catching juveniles and brooders in the back waters. For this reason, the tribal society rotate consumption of variety of foods in certain season due to non-availability of certain resources and hence alternative subsistence is found based on their traditional calendar. Most notable observation was shift in seasonal farming operations depending on onset or withdrawal of monsoon besides restarting short duration crops after cyclonic storms.

Cultivation and maintenance of roots and tubers

Roots and tubers play an important role in tribal diet in many parts of the tropical islands as they are most suitable for humid tropical region and have wide diversity in natural conditions. Nicobarese consider tuber crops such as greater yam, colocasia, tannia,

Fig. 4 — Diversity of climate resilient tubers used by Nicobari community

sweet potato, cassava, arrow root and tacca as the staple food supplying carbohydrate[21]. They have very good knowledge on different types, its habitat, cultivation and its cooking methods (Fig. 4). Studies have proved that considerable amount of selection and domestication process has happened in these islands over the period of time that helped them to select drought tolerant lines. In general, the tuber known as *kunya* is available throughout Nicobar followed by other varieties. *Sabudhan* (cassava) is also a widely grown tuber in their plantation area. It is popularly known as '*malayaliaalu'*. *Kupeng* or *takinihi* is a black color tuber and used for consumption after processing. Other varieties of tubers found in the study area are mainly *lěchlòng*, *vian* or *junglyaalu*, *ukov*, *tihaňlöo*, *kayun* or *walanj*.

After harvesting of matured tubers the adjoining soil is ploughed with hand hatchet till the soil is loosened to make a pit for replanting (seed tubers) based on their seasonal calendar. The pit is filled with dark colored surface soil rich in organic matter and crop residues which can hold soil moisture. They also known to apply ash into the pit and smear it on the cut surface of the tubers used as planting material. Sometimes they go for exploratory collection of roots and tubers deep inside the forest at specific time and plant some of them in their homestead garden. They follow two principles, Rē-taka (time for growth) and Taneuch (manure or good soil) but the performance depends on *kumrah* (rain) and moisture conservation.

Traditional knowledge on processing and storage

Coconut is the major plantation crop in Nicobar Islands and their agricultural activity is centered on

Table 3 — Type of receptacles used by Nicobari tribes

Name & Diversity index	Varieties / local types	Description and purpose	Climate adaptation
Receptacles (plate / cup to serve food) (0.67)	*Roi Kinrul*	The round and big size leaves of *rui* tree are used as receptacle for packing and serving food besides as wrappers for boiling pandanus, processed tubers and banana.	Well adapted to grow under high rainfall condition under dense canopy cover
	Tö Siöp Roita-òkö	It is prepared with half dried coconut spathe	Well adapted to coastal condition
	Rafoh	Arecanut spathe is cut into plate for serving ceremonial food	Grow in all places except waterlogged condition

the coconut plantations. Nicobarese process coconut into different forms *viz*. drying of nuts for copra, scrapping kutcha *malai* (copra) for extraction of oil, extraction of fiber from husk for coir, use of shells as firewood as well as for craftwork. *Hakuvan* is another method of extracting oil from scrapped raw kernel by boiling and cooling in the hot sun[22]. All these activities are greatly influenced by the availability of sunlight and rain free days. The tribal are known to adjust these activities in different years based on the prevailing weather parameters.

The Nicobarese are also known to shade dry some of the tubers and wild vegetables before storing for future use. Similarly, after harvest of tubers they arrange these tubers systematically in the cane or bamboo bin erected on stilt inside the house. The products are kept safely without damage or foul smell up to 7-8 months. The *Nicobarese* also use bark, coconut and arecanut spathe, dry coconut shell, bamboo stem, wild leaves with slight modification as receptacle for serving the food and drinks particularly during feasting and ceremonial occasions (Table 3). This helps to maintain the freshness of foods and minimize microbial infection during storage. In addition, they process surplus fish catch by traditional methods into fish pickle, sauce and dried fish (*Kāk anykuö)* for future use or during scarcity of vegetarian diet. Knowledge on processing and storage is vital for improving the adaptive capacity of tribal to climate change as these islands receive copious rainfall and the humidity is above 85% during August–October.

Anecdotal network based on respondent understanding of climate change

The anecdotal visitation network consisted of nine climate change adaptation measures and eight climate change indicators (events) (Fig. 5). The network analysis showed that seasonal calendar (strength = 6.55) and organic waste management (strength = 6.12) were the best climate resilient practices known to tribes followed by land use / holding. This is very essential to adapt to extreme events, moisture stress and long dry spell. The concept of bioshield is well known to the tribal elders as a natural protection against sea surges though some of the farmers group didn't recognize its structure. Use of traditional cultivars of banana and pandanus has profound importance in adapting to climatic stress and uncertainty. Further, food processing and multipurpose garden provide more stability to the tribal farming systems against any climate related variations and stress.

Discussion

Climatic variability over Nicobar Islands has been significant as indicated by recent analysis and most of these changes are on seasonal pattern of rainfall, coastal salinity, soil moisture, maximum-minimum temperature and occurrence of extreme evens[4]. In this context, the present study indicated that the Nicobari tribes are reasonably aware of climate related problems linked to rainfall, wind, cyclones, and sea surges and believe in their traditional wisdom to sustain them by effectively managing their resources.

It was observed that the land ownership remains with the tribal society and no division or transfer right is allowed to individuals or outsiders. This lineage unity is instrumental in economic activities ranging from clearing of forest patches for new garden, cultivation in *tuhet* or community gardens, fishing, hunting and sharing of surplus food items. This transcends into social norm wherein *tuhet* or tribal group is responsible for caring orphaned children and elderly people which strengthen the tribal adaptive capacity and enhance it from outside support in case of natural calamities as evidenced during the tsunami of December, 2004. These kind of community-based land management strategies were also reported among Loita Maasai (Kenya), Miskitu (Nicaragua) and Dayak Jalai (Indonesia) tribal groups to play a significant role in reversing deforestation, thereby carbon sequestration and rural livelihood. The multiple land-use systems as a livelihood strategy and

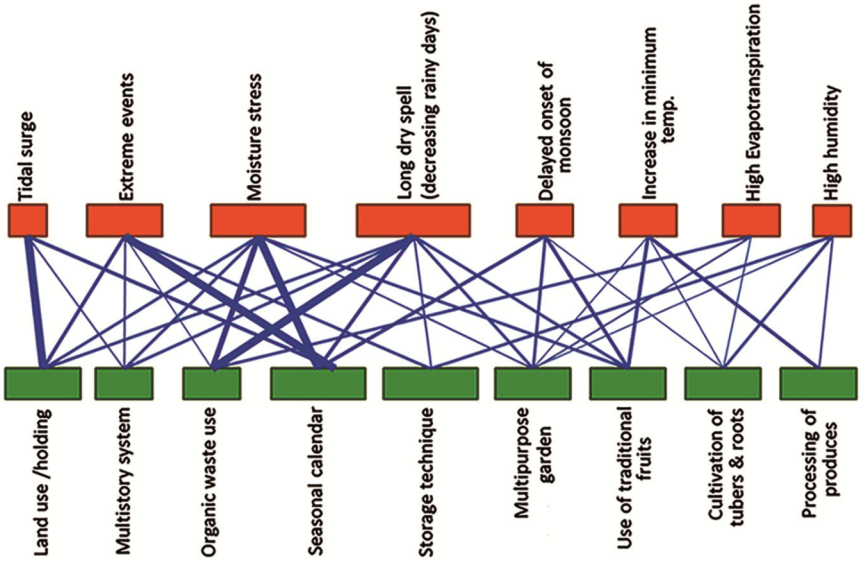

Fig. 5 — An anecdotal adaptation network constructed from tribal participant perception of climate change

source of resilience is worth to emulate as it greatly helped the local communities during extreme events.

Another distinctive feature is the presence of home gardens having diverse plant species like other tribal communities elsewhere[23]. The home garden is the result of accumulated knowledge practiced and managed over generations having multifarious functions such as food and nutritional security, family health by providing medicinal herbs, conservation and sustainable utilization of plant biodiversity[8], maintenance of soil fertility[23], most adaptable and accessible land resource that could reduce vulnerability to climate change, i.e. continuous adaptation to changes in environmental and living conditions, encountering the potential impacts of climate change. At the same time the multipurpose garden with highest diversity ensures sustainability and utilization of soil moisture and nutrient uptake from different soil depth[24]. This is important to adapt to changing rainfall pattern and resultant moisture stress besides minimizing soil erosion (4-10 t ha^{-1} yr^{-1}). Further, the tribal cultivation methods allowing crop residues to accumulate on the surface or around the tree trunk prevent moisture loss and improves the moisture retention and soil fertility. This indigenous practice replenishes depleted soil nutrients and also found to improve soil porosity (15-20%) and bulk density (1.10 to 1.25 Mg m^3) resulting in high infiltration and recharge of ground water[25].

The multistory cropping in home gardens with diversification and integration with poultry and livestock would play a significant role in reducing the risk of crop failure, provide immediate access to food will prevent starvation and ensure food and nutritional security[26] of the indigenous people under climate change conditions. It is also observed that tribal farmers practice staggered planting as a tradition that help them during long dry spell or extreme events and there is limited chance for outbreak of pest or diseases.

Among the traditional crops used by the tribals, tubers and roots being climate resilient can adapt to a wide range of agro-climatic conditions and give good performance even under marginal growing conditions. Most importantly *Pandanus* spp. acts as a bio-shield and protects the coastline from shoreline erosion, flooding, storms, reduces wind speed and subside the incoming tidal waves. In many tropical coastal areas, screw pine (*Pandanus facicularis*) is part of the coastal vegetative/green belt to protect the coastline[27]. In addition, the fair knowledge of seasonal calendar also helped them to evolve contingency plan / cropping to cope with unexpected situations.

The tribal knowledge on establishing or maintaining the sequence of plant layers from the coastline is worth to upscale to other places. The tree / plant species grown in the bioshield can tolerate salinity and water logging. Several studies on tribal knowledge also showed that growing different crops and varieties with different susceptibility to drought and floods and supplemented by hunting and fishing enable the tribes to cope with climate related risks[28]. Furthermore, the

processing and storage methods practiced by tribals are very helpful to store surplus food item even under varying climatic conditions (humidity and temperature) for longer durations. Thus, the deep insight into the traditional farming knowledge of Nicobari tribes highlighted its climate resilience and importance in sustaining tribal livelihood.

Conclusions

The above paper documented the traditional knowledge in various aspects of the livelihood of Nicobari tribes involving land use pattern, multipurpose home gardens, climate prediction, seasonal calendar, crop management, processing and storage of surplus produce which were gained over the years. The community land management is the basis for their sustenance and the entire adaptive mechanism revolves around the sharing of resources among themselves. The knowledge on biodiversity, its use and conservation provide them diverse food items whereas their acumen into the island resources helped them to judiciously utilize for their economic advancement. Thus, the community based adaptation measures based on priorities, needs, knowledge, and capacities of local/ indigenous communities should be evolved to empower the locals to plan and cope with the impacts of climate change.

Supplementary Data

Supplementary data associated with this article is available in the electronic form at https://nopr.niscpr.res.in/jinfo/ijtk/IJTK_23(01)(2024)6-15_SupplData.pdf

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Prior Informed Consent

The authors declare that prior informed consent was taken from the respondents for collecting the data for the present research work.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Contributions

AVM: convinced concept, analyzed data and prepared manuscript; TPS: perceived concept, managed project, analysis and reviewed manuscript; IJ and SKP: carried out data collection and supported review; ASP and NR supported project management and reviewed manuscript.

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